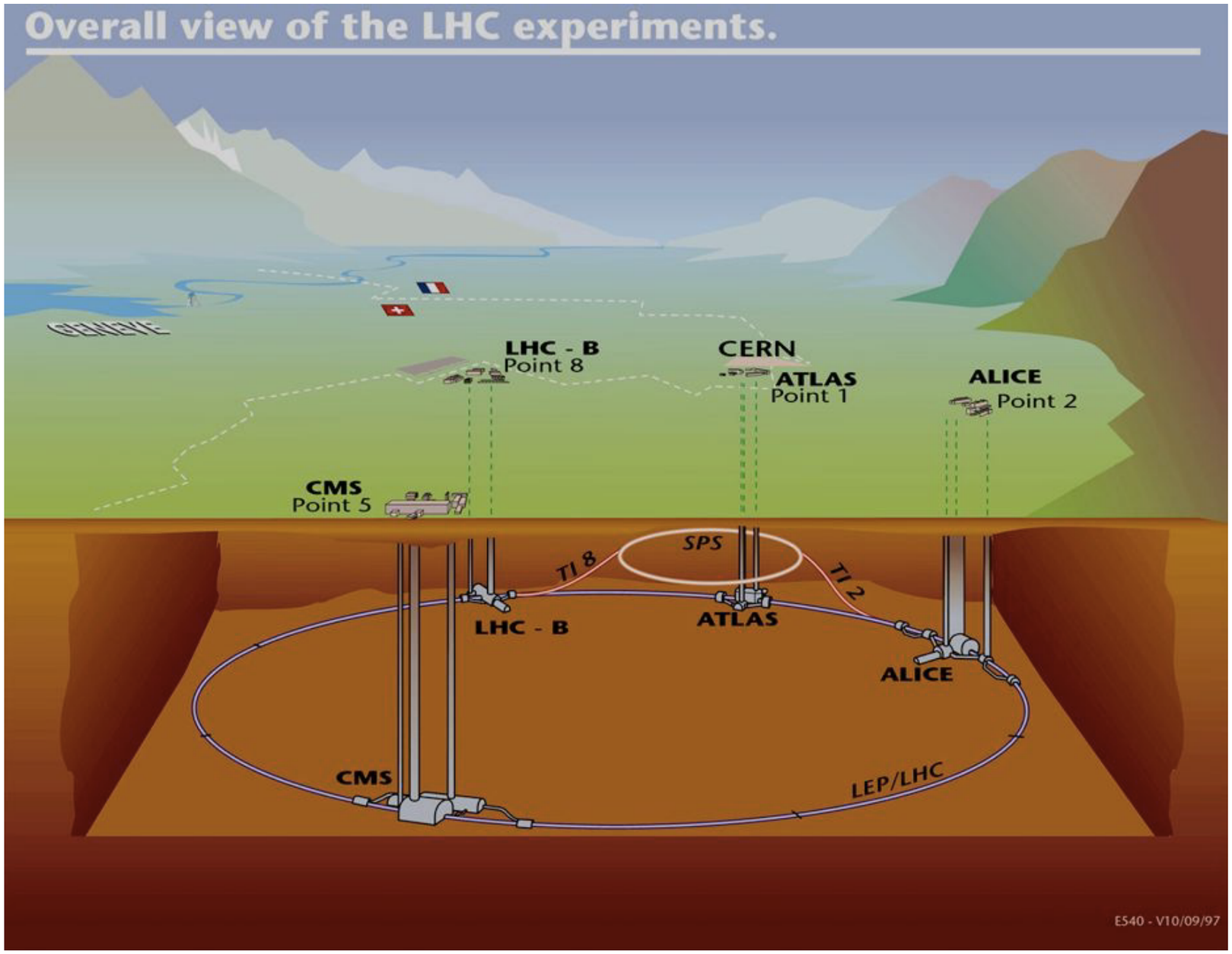
Luciano Maiani: Lezione Fermi 25

Making the LHC

1. Normal sufferings
2. ...and major crises: LEP
3. The cost crisis
4. LHC startup
5. L'incidente di settembre
6. I costi di LHC

Costruzioni civili per LHC:

- sale per ATLAS e CMS con relativi pozzi di accesso
- 2 tunnel di accesso dei protoni da SPS
- riadattamento del tunnel di LEP



1. Normal sufferings...ground freezing at the CMS shaft

2..and major crises: LEP was the first

LEP in the year 2000

- LEP has obtained important results in the last months of operation in the year 2000
- evidence for a Higgs particle at about 115 GeV/c^2.
- LEP Collaborations requested a further run in 2001(from May to October) in order to consolidate the data.

Agreement with SM Higgs cross-sect. for

$m_H = 115.0^{+1.3}_{-0.9}$ GeV

P. Igo-Kemenes - LEP Seminar - Nov. 3, 2000

Statistical Significance

2.2σ	September 5
2.3σ	LEP fest
2.9σ	November 2

Preliminary!!

- Run in September and October has been very beneficial: significance increased, better understanding of background

What to do next?

L.Maiani 9 Februay 2001 LEP @ICFA 4

Brief Chronology

Institutional Committes have been consulted on LEP running in 2001

- **LEP C (Nov. 3) no consensus on a positive recommendation**
- "**...** the combined evidence for a Higgs near 115 GeV already to be quite significant and considers that there are sizable prospects for a major discovery to be made at LEP, but also a non-negligible risk that no definite conclusion would be reached.
- Therefore, considering only LEP and its operation costs, the committee considers that an extension in 2001 to collect 200 pb^{-1} above 208 GeV would be justified.
- However the committee also recognises that an extension could have a serious impact on the LHC and, in view of this, there was no consensus to recommend an extension. "
- **Research Board (Nov. 7) no consensus on a positive recommandation**
- **Scientific Policy Committee was consulted permanently, and reported to CC**
- **The issue arrived to the CERN Directorate on Nov. 8**:
- The Directorate considers that the risk of a major delay of LHC and the extra cost do not justify a LEP run in 2001. Therefore, the Directorate maintains that the existing programme is the best way to address this physics and unanimously does not accept the request to run LEP in year 2001.

Epilogue: Committee of Council, Nov. 17

Scientific Policy Committee: majority in favour of stopping LEP

Final CC Statement

"On 17th November 2000, the CERN Committee of Council held a meeting to examine a proposal by the Director-General concerning the continuation of the existing CERN programme, which foresees the decommissioning of the LEP accelerator at the end of the year 2000.

The Committee has expressed its recognition and gratitude for the outstanding work done by the LEP accelerator and experimental teams.

It has taken note of the request by many members of the CERN Scientific Community to continue LEP running into 2001 and also noted the divided views expressed in the Scientific Committees consulted on this subject.

On the basis of these considerations and in the absence of a consensus to change the existing programme, the Committee of Council supports the Director-General in pursuing the existing CERN programme."

LEP data-taking is finished and we are moving into the LHC era.
CERN staff and LEP Collaborations have made a tremendous efforts over the time of LEP, which have led to many exceptional achievements,
notably the recent evidence for a Higgs particle at a mass of 115 GeV.

CERN-EP/2003-011
13 March 2003

Search for the Standard Model Higgs Boson at LEP

ALEPH, DELPHI, L3 and OPAL Collaborations
The LEP Working Group for Higgs Boson Searches[1]

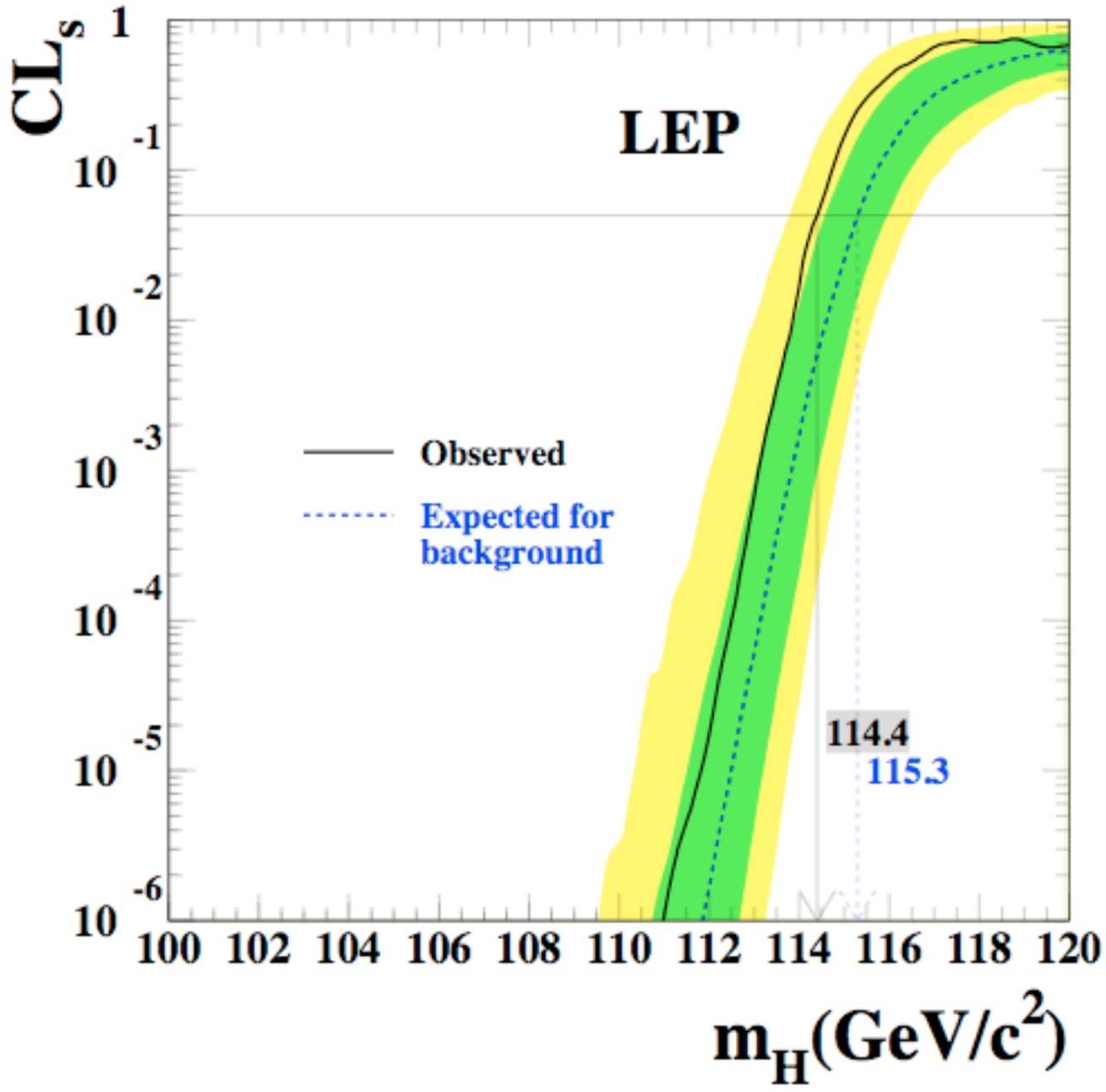
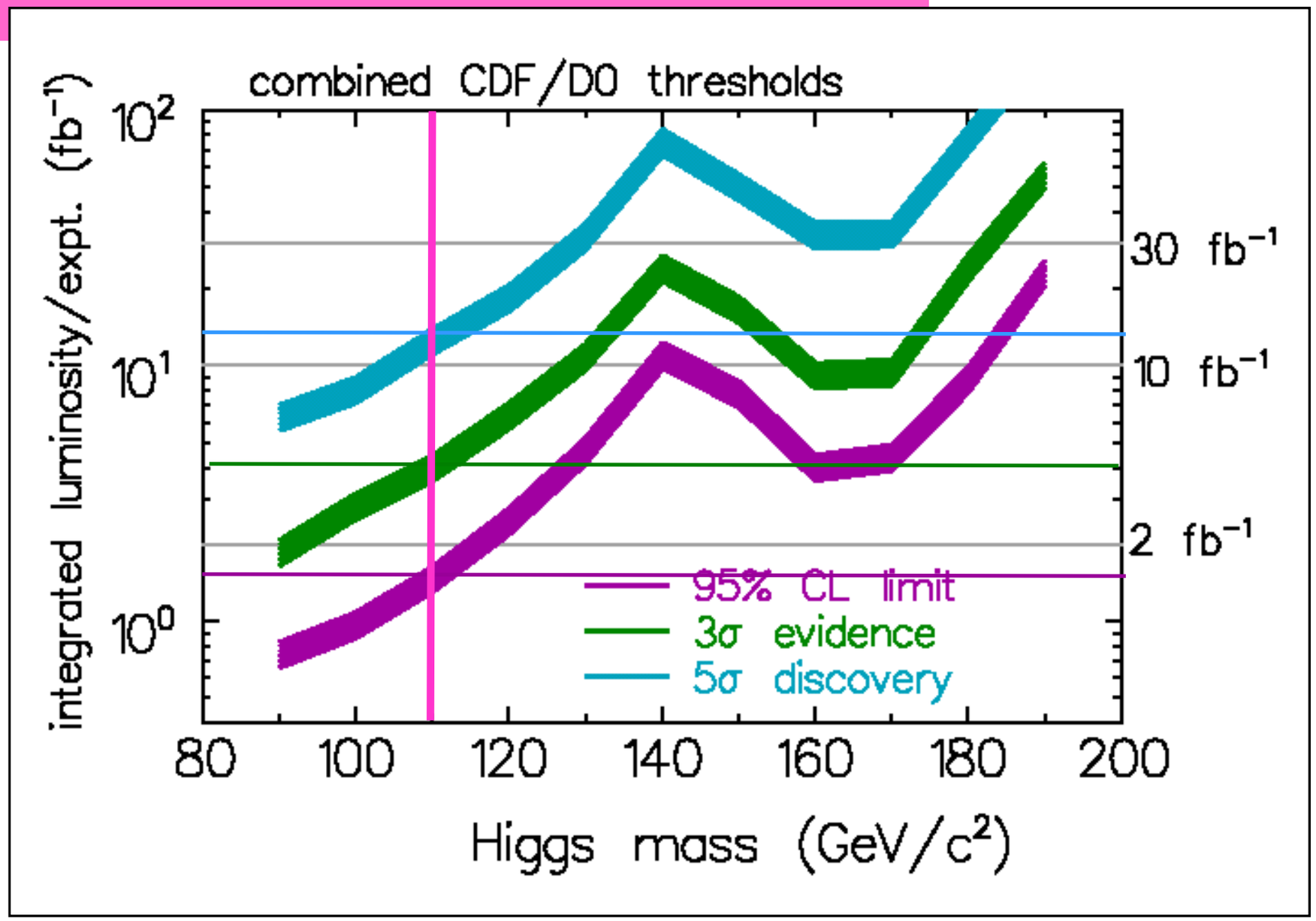
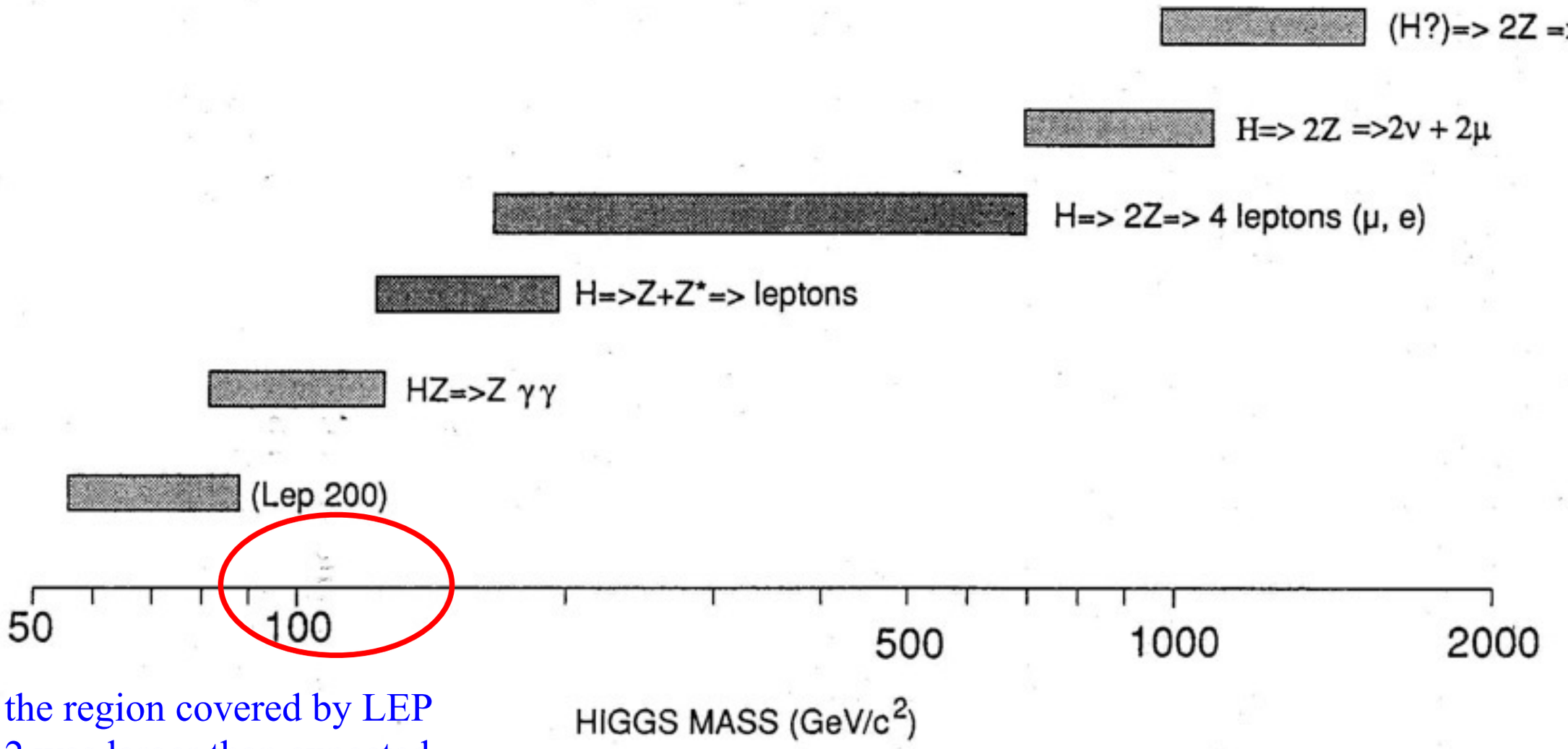


Figure 9: The ratio $CL_s = CL_{s+b}/CL_b$ for the signal plus background hypothesis. Solid line: ob-

Tevatron discovery potential



SEARCHING FOR THE HIGGS AT LHC



the region covered by LEP 2 was larger than expected, very crucial for the LHC !!

Figure 4 – The primary Higgs signatures at the LHC

June 2001
Magnets from Novosibirsk

Status report on the LHC machine

Lyndon Evans

Scientific Policy Committee

CERN, Geneva,

10-11 December 2001

UX15 cavern seen from the LHC tunnel

3. The cost crisis

- In summer 2001 we received the replies to the call for making the 1232 magnetic dipoles, the biggest contract, and the cost of the escavation of the ATLAS and CMS halls could be made with good approximation
- A conference of the groups dedicated to LHC construction was made and a cost to completion could be estimated reliably
- at the same time, we coud make a cost estimate for the upgrading of the CERN infrastructures needed to host the LHC, which was now becoming a reality
- A shortfall of money was found, with respect to the projected budget, and a big crisis started, which lasted until the end of 2002

The LHC extra cost to completion: main figures

Presented to the External review Committee, Jan 2002..

Sept.19 talk
480
150
50
120
40
≈10

The model following the cost review and the assumptions above are:

LHC machine and areas construction	+ 475.0
Prototyping	+ 143.0
CERN share of detector construction and M&O	+ 56.0
LHC Injectors	+ 26.0
LHC computing Phase II	+ 120.0
LHC infrastructure and support(*)(machine & detectors)	+ 53.2
Radioactive waste management	+ 14.0
	+ 887.2
Cut for LHC prototyping (over 2001-2008)	- 143.0
Cut in R&D	- 25.8
Cut in consolidation	- 18.0
	- 186.8
Balance	+ 700.4
Missing in-kind contributions	+ 40.0
Total	**740.4**

Corresponds to the materials margin not allocated to the Remuneration Review (CERN/FC/4360/corr.) distributed so as to increase the support provided to the LHCproject and the related CERN infrastructure.

Further Assumptions:
Special Indexation of Host States stops after 2005
From 2006 onwards indexation keeps purchasing power

... a tough cure, a balanced package

In very rough figures:

- savings:
  - reduction in science programme with recuperation of manpower, rescheduling (required by cable production) ...more control...(about 300 MCHF)
- extending repayment period from 2007 to 2010 (about 400 MCHF)
- CERN came out leaner but more focussed....will see...

An opportunity for CERN

Chinese symbol for CRISIS (危机 contains two characters

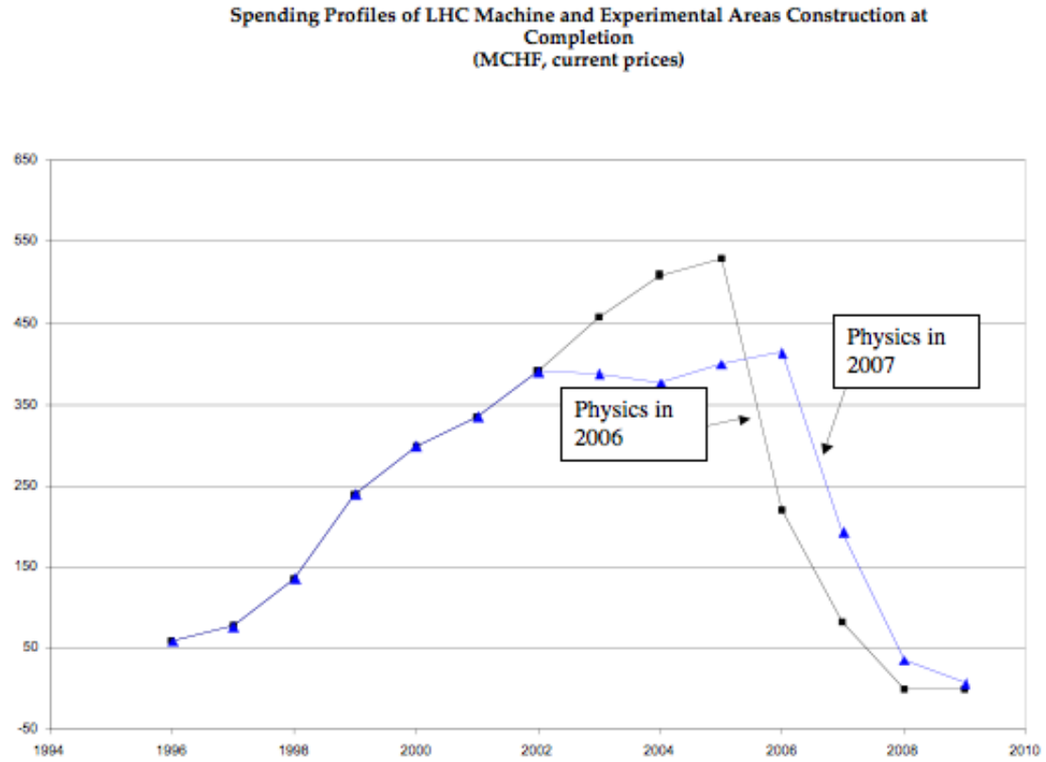
That for DANGER (危险 and

That for OPPORTUNITY (机会

Present crisis should be viewed in a balanced way. Clear dangers

but also clearer opportunities coming to light

l'ultimo tornante: il picco delle spese



.....Il negoziato fu condotto abilmente da André, anche grazie all'appoggio di Bousquin e, presumo, di Prodi: .. la BEI prospettó un finanziamento di 300 milioni di Euro al tasso del 4% (quello concesso alle istituzioni con tripla A) da restituire entro il 2010.... la quadratura del cerchio del finanziamento di LHC.

A quel punto il Consiglio dette il via libera alla trattativa e poco dopo il prestito al CERN, una prima assoluta nel campo della ricerca in Europa, veniva approvato all'unanimità dall'Ecofin, il Consiglio dei Ministri Europei delle Finanze, per l'Italia il Ministro Giulio Tremonti.

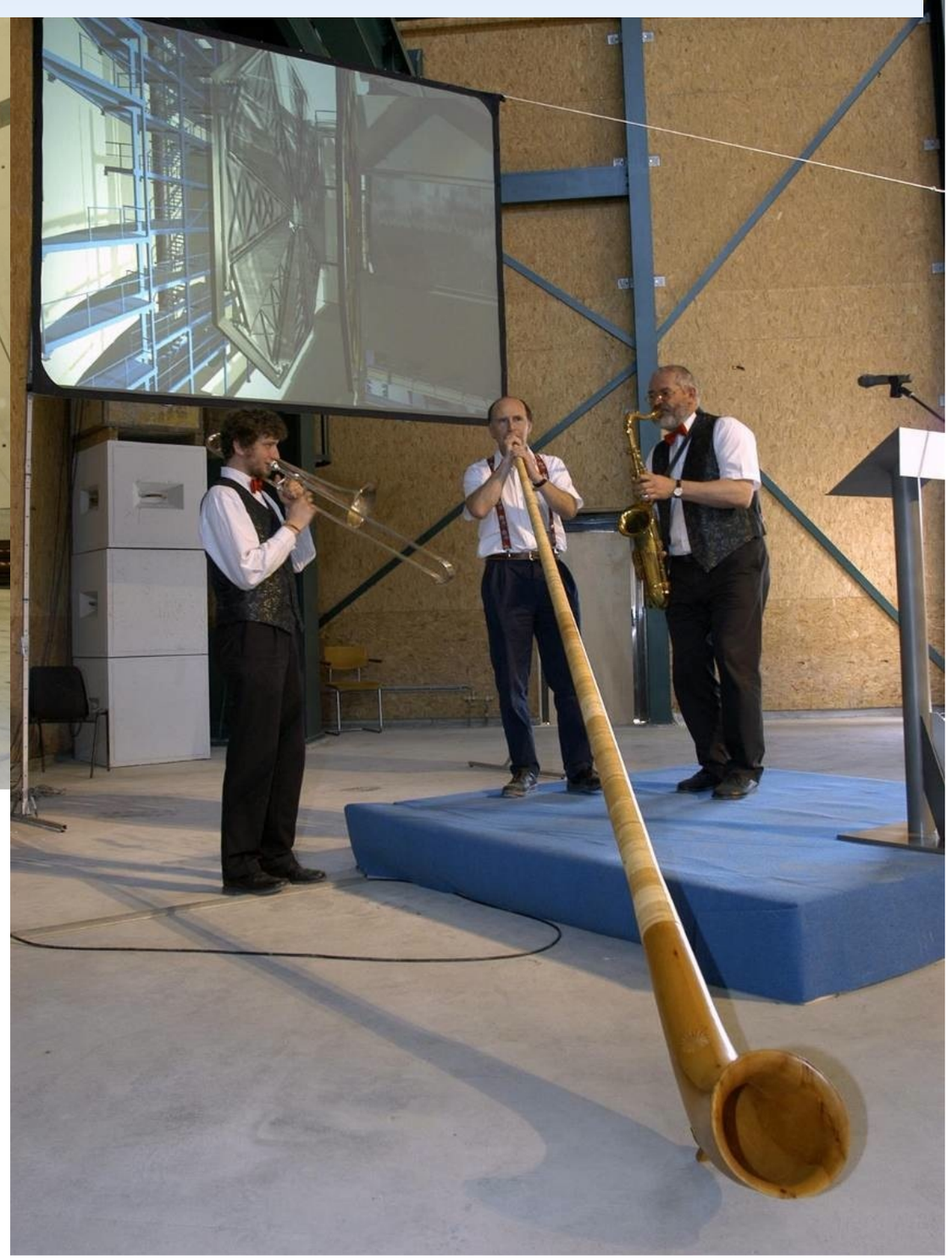
L'accordo definitivo, per un ammontare di 300 milioni di Euro, fu siglato a Bruxelles da me e dal presidente della BEI il 19 dicembre 2002, alla presenza del Commissario Bousquin e del presidente del Comitato finanze del CERN, Jan Bezemer. Nelle sue conclusioni, Bousquin esprimeva l'augurio che questo accordo avrebbe 'aperto la strada ad iniziative simili che promuovano gli ulteriori investimenti essenziali per la ricerca e l'innovazione in Europa'. Un augurio finora senza seguito.

• CERN has profited from Cost-to-Completion crisis in 2001 to enforce real changes;
• A leaner programme, a well-focused Laboratory;

- With less reservation than last year, we can confirm the LHC schedule:
  - completion of the LHC machine in the last quarter of 2006,
  - first beams injected during the spring of 2007
  - First collisions mid 2007.

ATLAS Cavern Inauguration 2003

x 4



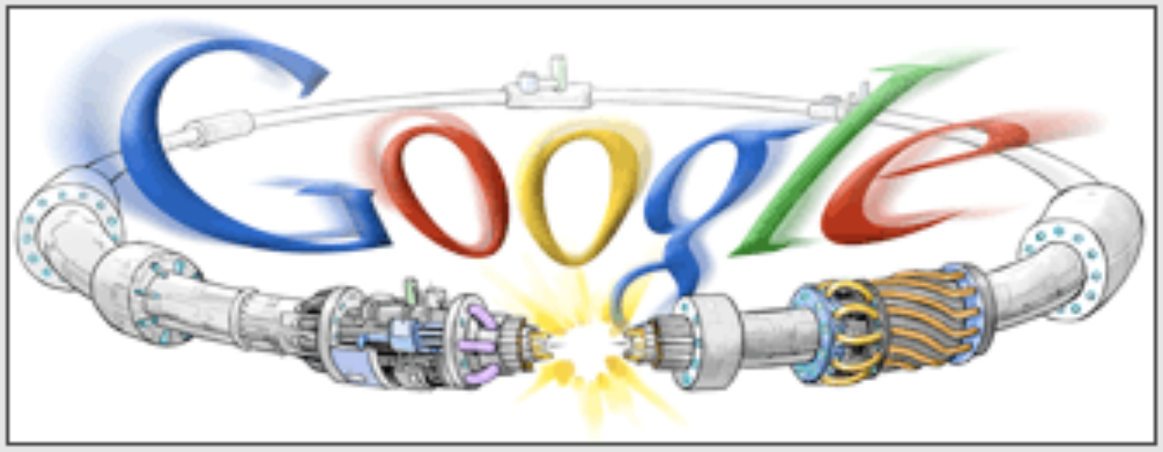
Magneti per LHC in deposito

La “stringa” di 120 m

GOOGLE and the LHC

Google LHC Logo

Today, Google place a different logo for their homepage having Large Hadron Collider (LHC) experiment theme.



We can easily see the excitement about this LHC experiment on any face who have interest in science and scientific things specially in physics as this would be the future of physics.

Scientists at the CERN research centre in Switzerland are aiming to use this wonder machine to gain a better understanding of the birth and structure of the universe, and to fill gaps in our knowledge of physics.

Well, it's a big topic to discuss...I am not that much intelligent...however a well known **Prof Stephen Hawking** said that "Whatever the LHC finds or fails to find, the results will tell us a lot about the structure of the universe."

Cheers!

September 10, 2008 - Posted by **imstrategist** | **Uncategorized** | **Google, LHC Experiment** | **1 Comment**

1 Comment »

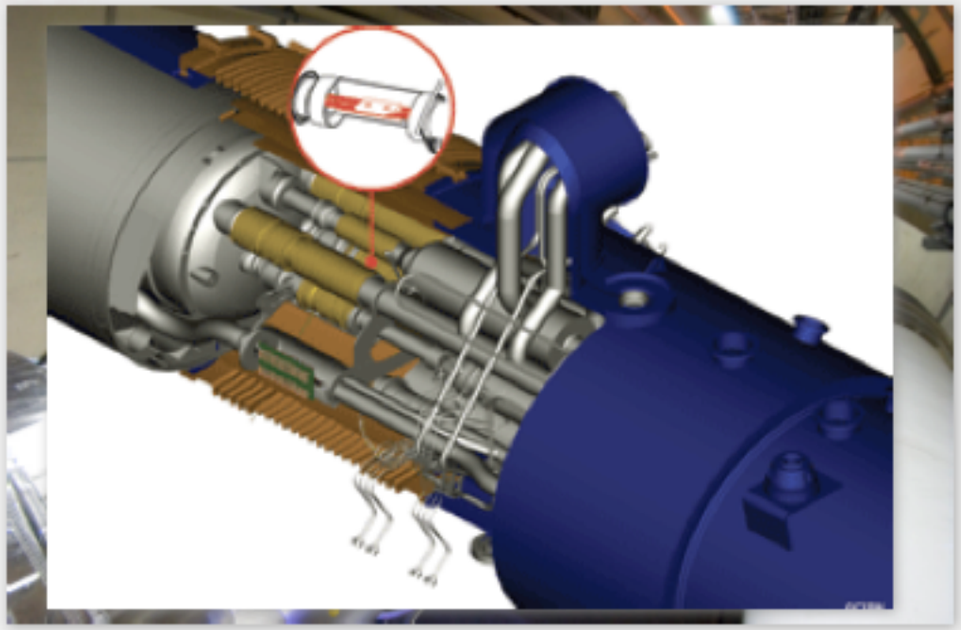
1. Yaaay, im still alive, no black holes

   Comment by ZeroZool | September 10, 2008

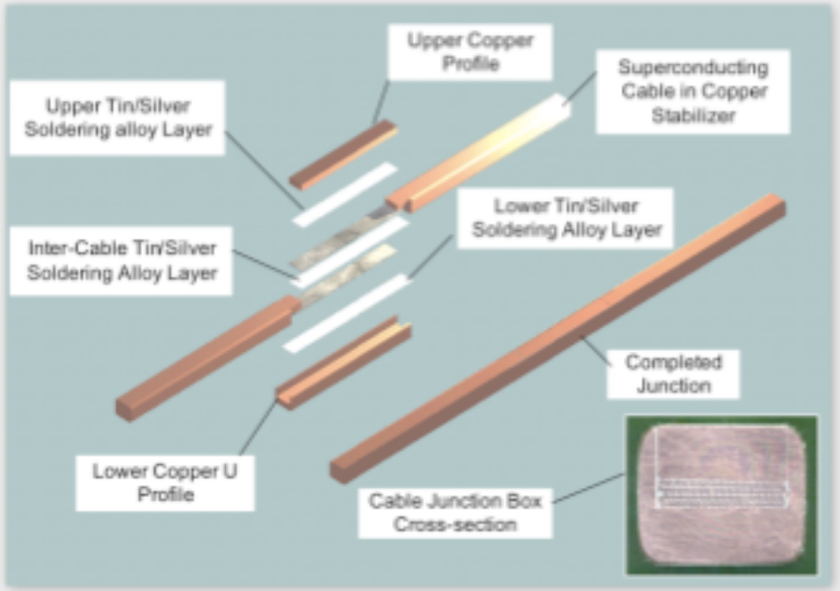
4. LHC Startup, 10 Settembre 08

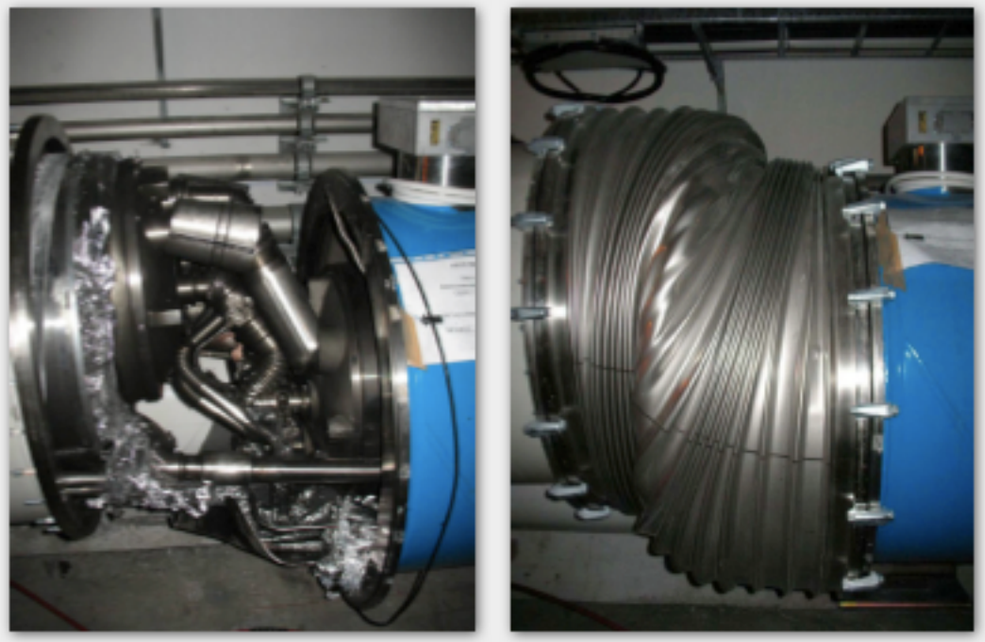
10th September 2008

September 19, 2008: incident in sector 3-4



The incident was traced to a faulty electrical connection between segments of the LHC's superconducting cable
(busbars)
High impact was caused by collateral damage





2 most severely damaged interconnects

53 Magnets (along a zone of about 700 m) to be removed from tunnel and repaired/ exchanged (a few % of entire LHC)

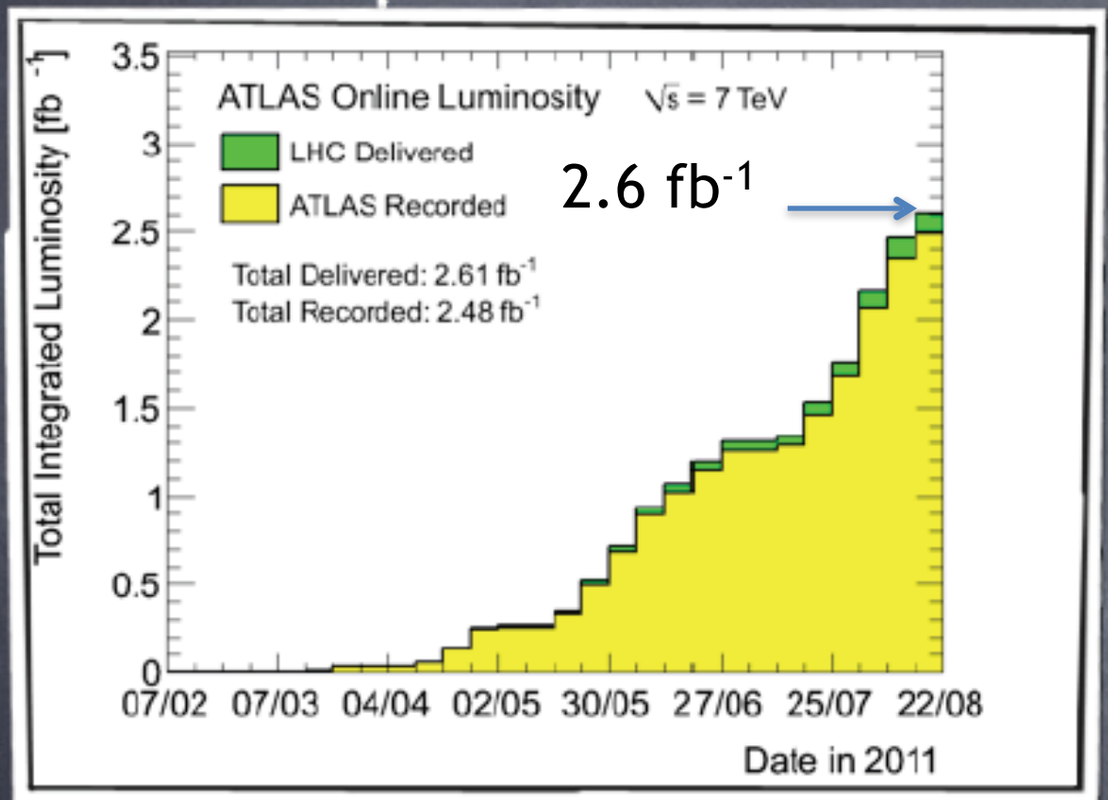
Last of 53 repaired magnets back in the tunnel

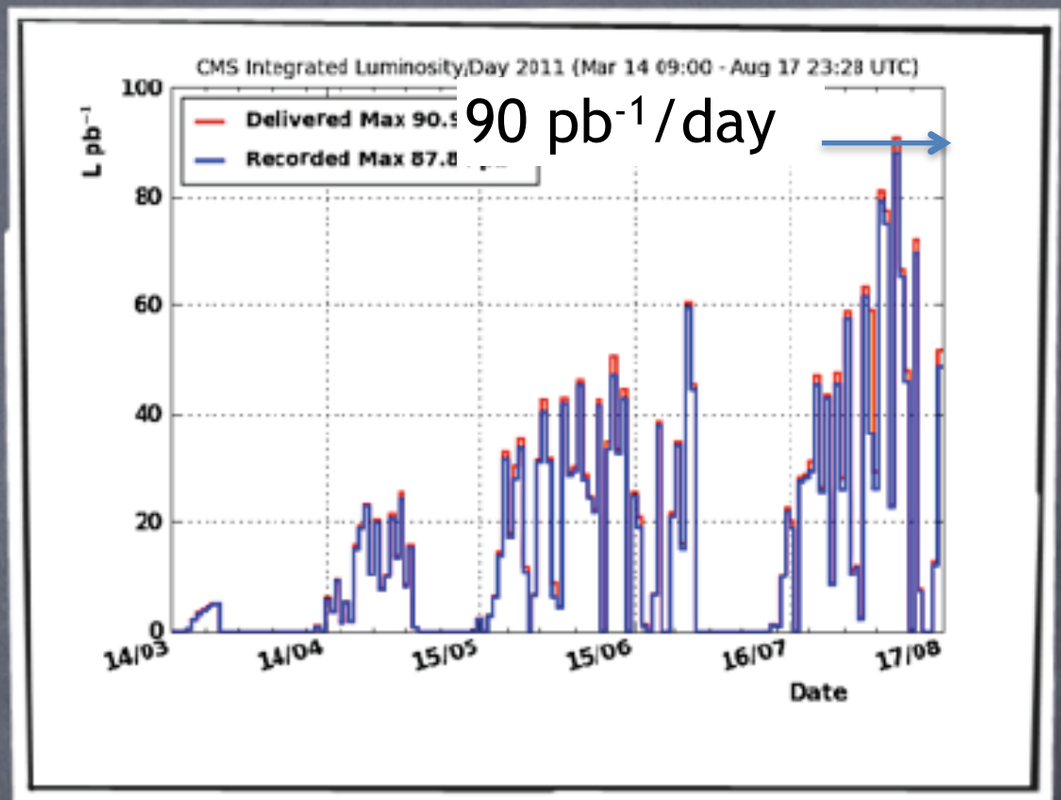
The Latest from the LHC

The 53rd and final magnet for the Sector 3-4 repairs was lowered into the tunnel on Thursday, 30 April, marking the end of repair work above ground.

2011 - Oh What a Year

- The new thumb rule:
  ~500 pb^{-1}/week and more to come





- 50 ns bunch trains with 6-8 interactions/crossing
- The analyses presented here are based on 1-2.3 fb^{-1}/experiment

6. Costi stimati (Dicembre 2002) e costi dichiarati a fine progetto (Maggio 2009)

Tab. 6A. LHC construction: all-out estimate

- Includes cost escalation of contracts and PE cost
- Gives an absolute ceiling to the total cost to CERN (current prices)

	1995-2001	2002-2007	Total
Machine Hardware, Installation & Experimental Areas	1006.0	2071	3077
Test & Preoperation (includes additional infrastructures, 94 MCHF)	38.4	226	264
LHC Injectors	35.2	36	71
Contingency			140
Cost Escalation of contracts			191
TOTAL MATERIALS			3743
Personnel	368.5	661	1029
Indexation of PE cost			30
GRAND TOTAL			4802

FC, Dec. 11, 2002 L. MAIANI. Baseline Plan 17

Per i rivelatori qui ci sono solo i costi al CERN.
Il costo complessivo dei 4 rivelatori deve essere intorno a 1500 Milioni di CHF.

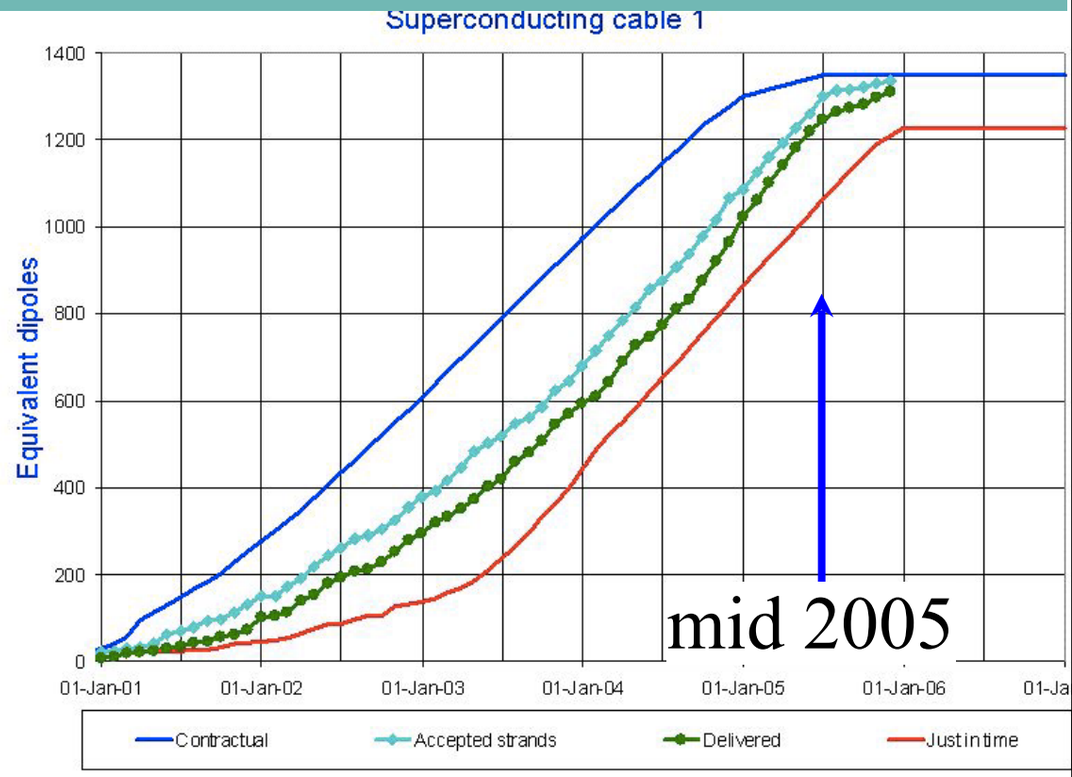
	Personale	Materiale	Totale
Macchina e Aree Sperimentali	**1 150**	**3 685**	**4 835**
Iniettori	**86**	**67**	**153**
Rivelatori: costruzione, R&D	**879**	**312**	**1 191**
Rivelatori: test e pre-operazioni	–	**181**	**181**
LHC Computing	**86**	**93**	**179**
Gran Totale	**2 202**	**4 337**	**6 539**

Building lhc was a great enterprise which cern led with great skill

1.1. LHC Schedule

- Contracts for dipole cold mass
  CERN has a double role: supplier of SC cables, end-customer of the dipoles. We must be prudent in defining the dipole delivery schedule, hence the LHC schedule.
- SC cable production to end mid 2005;
- last dipole delivered July 1st, 2006;
- Machine closed and cold: Oct. 2006;
- First beam: April 2007;
- First physics: mid 2007;
- Very solid foundation of the LHC confirmed by SC cable panel and Machine Advisory Committee.

L. Maiani. March 21, 2002 Committee of Council 8



- 1.5 year delay due to problems with QRL
- another 1.5 year for the accident
- later resolved by Steve Myers

Sept. 10th 08: first beams

- useful beams: 2010
- Higgs physics: 2011

Lyn Evans and Lucio Rossi receive at CERN the last dipole